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August 15, 1997

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Mr. William F. Caton,
Acting Secretary
Federal Communications Commission
1919 M Street, N.W. Room 222
Washington, D.C. 20554

RE: In the Matter of Federal-State Joint Board on Universal Service - CC Docket No. 96-45

Dear Mr. Caton,

The Joint Sponsors of the Benchmark Cost Proxy Model (BCPM) have submitted the attached information to the Commission's Universal Service Branch on this date. The BCPM Joint Sponsors include, BellSouth, Sprint, and U S WEST.

The attached information is comprised of documentation for the BCPM-Switching Module (BCPM-SM). This supplements documentation submitted by the Joint Sponsors on August 8, 1997, for the transport and signaling modules.

BellSouth, Sprint and U S WEST request this information be made a part of the record in this matter. Two copies of this letter, in accordance with Section 1.1206(a)(1), is provided for this purpose. If there are any questions, please feel free to call.

Sincerely,

Warren D. Hannah

Warren D. Hannah

Attachment

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DESCRIPTION OF THE BENCHMARK COST PROXY MODEL SWITCHING MODULE

PURPOSE

The BCPM—Switching Module (BCPM-SM) is designed to develop per line switching costs for Universal Service Fund (USF) applications and to support the development of switching costs for Unbundled Network Elements (UNEs). The Model fully supports a forward-looking economic cost methodology, and reflects generally available digital switching technology.

SWITCHING OVERVIEW[1]

Switch Functions

Central Office Switches provide the connection between a subscriber's local loop (access line) and the outside world. Modern digital switches can handle voice, data, and video signals as they link telephones, fax machines, and computers together on the public switched network. The functions performed by switches for universal service and UNEs include:

- Line Termination, or local interconnection to an exchange circuit (local loop).
- Line Monitoring, to ensure that requests for service (off hook) are reliably served.
- Call Processing, Routing, and Completion
- Interconnection to Interexchange Carriers (IXCs) and Wireless Carriers
- Billing and Maintenance
- Vertical Services and Features

Rate Elements Supported by Switching

Some of the primary network cost and rate elements supported by central office switches include:

- Line Port
- Line Usage

[1] This section includes information from the following sources:

Lucent Technologies, Inc., The 5ESS-2000 Switch, Available: http://www.lucent.com/netsys/5ESS/5esswtch.html

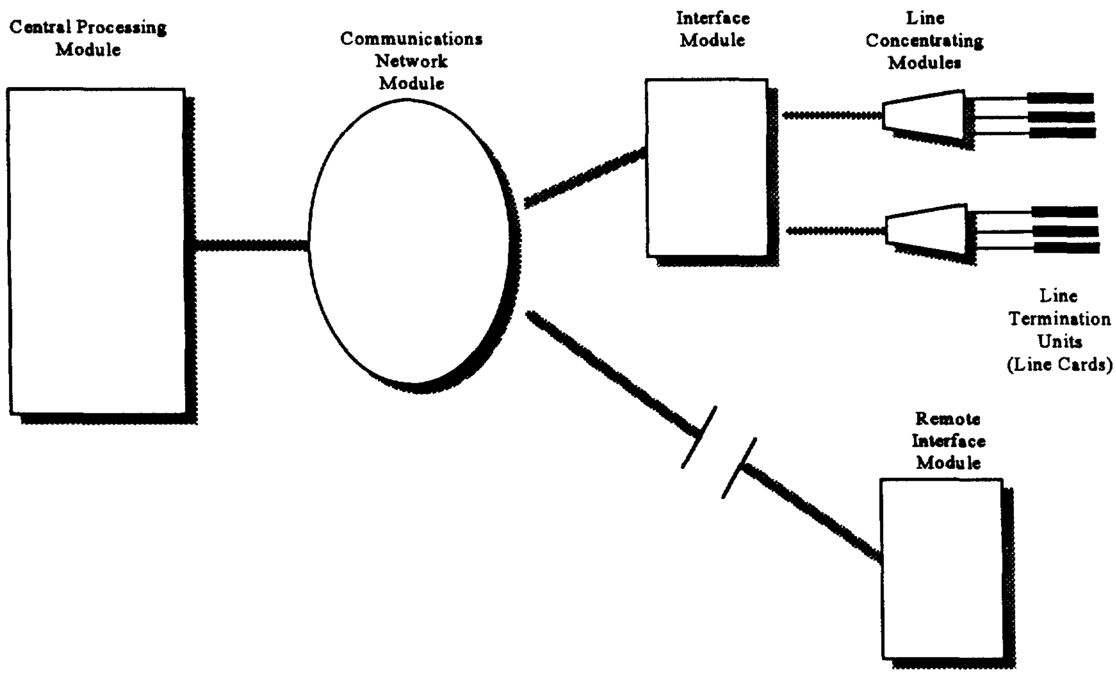
Motorola, Inc., Access!Motorola: Switching Solutions, Available: http://design-net.com/solutions/wired/switching/index.html

- Trunk Usage
- Local Tandem Switching (Part of Common Transport)
- Custom Calling, Centrex, and CLASS Features
- Signaling (Signaling System 7)

Switch Architecture

Modern digital switches are built in a modular fashion. This means that any switch can be configured in a variety of different ways by combining standard components. This allows the switch to be designed efficiently and flexibly, and allows the switch to grow as needed to support new subscribers and services. The same basic components can be used in different roles. For example, Line Termination Units and Line Concentrator Modules are used in host switches to terminate subscriber lines. When placed into a remote hut and connected to the host switch by umbilical trunks, these components can function as a remote "switch". In many cases, it is more economical for the telephone company to place such a remote than to install Digital Loop Carrier equipment to serve the same subscribers.

Typical Switch Architecture



The architecture of a modern digital switch can be described generically as having three components: the Central Processing Module, the Communications Network Module, and

Interface Modules. These three modules perform, respectively, central control, central call processing, and line termination/supervision. The two most common end office switches in deployment in the U.S. are the Lucent 5ESS® and the Nortel DMS-100®. We shall begin with the module that connects the subscriber to the network, the Interface Module.

Interface Module (IM)

The Interface Module (IM), known as the Peripheral Module in the DMS-100® and the Switch Module(SM) in the 5ESS®, contains Line Termination Units or Line Cards, Line Concentrating Modules, and Digital and Analog Trunk interfaces. Line Termination Units provide the dedicated circuit termination between the customer and the network. Line Concentrating Modules bundle or funnel the individual circuits into speech links which connect to the Communication Module. Typically, the IM provides one speech link for every two to six line terminations. Trunk terminations, however, are not concentrated. The IM provides what are known in the industry as the basic BORSCHT functions of the switch:

- Battery
- Overvoltage (protection from power surges)
- Ringing (power ringing)
- Supervision
- Coding/Decoding (analog/digital conversion)
- Hybrid Testing

Many, but not all, IMs have limited internal call processing capability which allows them to connect calls which originate and terminate within the IM even in the event of a failure in the host switch. In particular, the 5ESS® has microprocessors located within the SMs which enable a large proportion of calls to be handled without the involvement of the central processing unit, or Administration Module. This is not necessarily a superior design feature, but it does have important implications in the development of a valid cost model.

Communications Network Module

The Communications Module (CNM), also known as the Network Module (NM) in the DMS-100® or the Communications Module in the 5ESS®, is responsible for providing speech links between IMs. It is the core of the time-division-multiplexed switch fabric which efficiently connects and controls all of the major elements of the digital switch. The CNM also transmits the messages which pass between the CPM and IMs to coordinate call processing and administrative functions.

Central Processing Module

The Central Processing Module (CPM) comprises the Administrative Module in the 5ESS®, and the Central Control Complex and Input/Output Controllers in the DMS-100®.

The CPM is responsible for the establishment and coordination of connections though the switch. It sets up internal connections between lines for intra-switch calls and between lines and trunks for inter-switch calls. It is the central collection point for billing and performance information and provides interfaces to the external billing and performance monitoring systems. The CPM provides the interface with the SS7 network. Maintenance and administrative functions such as the establishment of customer service are controlled here.

In general, the CPM of the DMS-100® is more involved in routine call processing than that of the 5ESS®. In the 5ESS®, most call processing is handled by distributed microprocessors located in the CNM and IMs.

SIGNIFICANT CHARACTERISTICS OF BCPM-SM

BCPM-SM captures the unique characteristics of each switch or serving wire center. These characteristics include: 1) existing host/remote relationships; 2) usage differences between serving wire centers; and 3) technology differences between different switch models; e.g. the 5ESS® and DMS-100® switch models. It is important to model these serving wire center attributes for the following reasons.

First, investment varies significantly between a host switch and remote switch. As described above, the remote is little more than an Interface Module. It connects to and is dependent on the Communications and Processor modules located back at the host. Efficiencies garnered by utilizing the host/remote switch relationship are predicated on reducing switch investment required in a remote switch (i.e., the Processor and Communications modules) by enabling the remote to rely upon the intelligence at the host switch. This has important implications for determining the costs of universal service and UNEs. If all serving wire centers are modeled as stand alone switches, there will be a substantial overstatement of switch investment.

Second, differences in usage, both line and trunk usage, between serving wire centers have important implications for the requisite switch investment associated with a particular wire center. All other things equal, the greater the level of usage, the larger the switch investment to accommodate such usage. By reflecting the difference in switch investment associated with particular serving wire centers, the potential for inappropriately averaging switch investment across serving wire centers diminishes.

Third, depending on the switch model, different components may be used to perform certain switch functions. For example, the line port investment associated with a 5ESS switch is substantially less than the line port investment associated with a DMS100. These differences in switching systems have important implications for determining the requisite investment associated with a particular wire center. Having the ability to account for differences in switch types may mitigate the potential for averaging switch costs across serving wire centers.

METHODOLOGY

Overview Of The Process

Although determining per line switching costs for universal service entails numerous analytical steps, one can summarize the process in two major phases. First, the analyst generates per line switching costs by apportioning total switching investment across switch functions. Second, the analyst determines the type of switch function and the amount of each of those switch functions required to provide basic service. Aggregating the costs associated with the requisite switch functions enables the analyst to determine the switching investment per line required to provide basic service.

The conceptual difference between universal service and UNE costing is that for universal service the per line switching investment represents a complete basic service, including line termination and the ability to place local calls. For UNEs, switching investment is determined for a discrete network element, reflecting the appropriate increment for that element, e.g. switching investment per call waiting activation, switching investment per line termination, or common transport per Minute of Use (MOU). The individual UNE investments must be assembled to create a fully-functional retail service.

The following outlines this two step process in greater detail (refer to chart on page 7).

Ia. Switch Functional Investment Development Process

The objective of the first phase is to determine the unit switch investment (in dollars) associated with each switch function. For our purposes, we have reasonably identified six switch functions: 1) Getting Started Cost; 2) Line Port Cost; 3) Line Usage; 4) Trunk Usage; 5) SS7; and 6) Umbilical Usage.[2]

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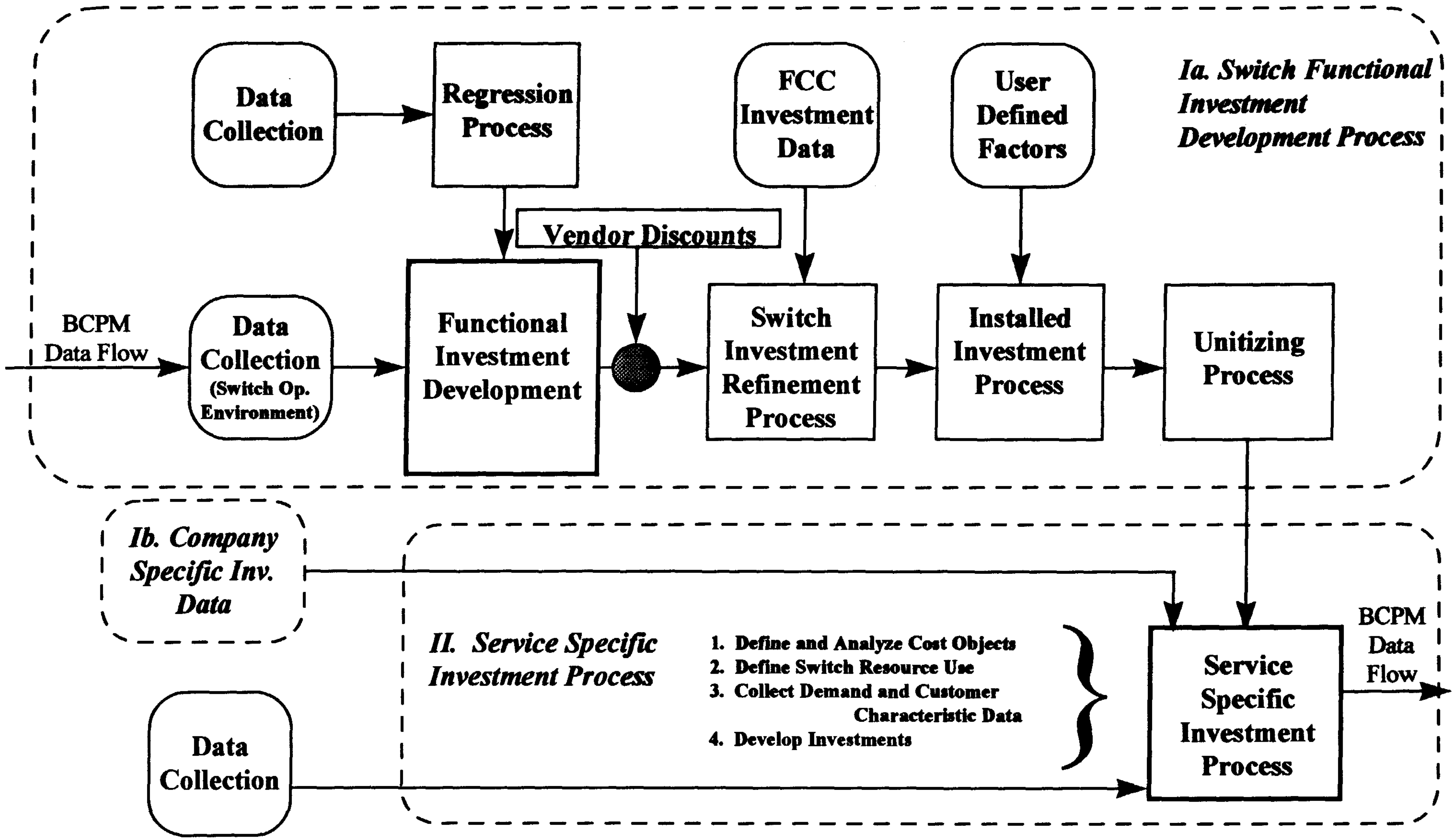
[2] The following briefly defines each of these switch functions:

1) Getting Started Cost—The minimum fixed investment required to provide switching, regardless of usage. It is composed primarily of the central processor and memory.
2) Line Port Cost—The investment required to terminate the local loop in the central office. It is composed primarily of a line card and other line termination equipment, the main distribution frame, and protector. This cost can vary widely depending upon the vendor-specific switch architecture.
3) Line Usage—The investment associated with usage sensitive line-side switching. It is composed primarily of the line concentrating module, DS-30A links, line group controller, DS-30 links, and the network module for the DMS-100® switch. For the Lucent 5ESS®, this cost includes equipment such as line interface units and various switch network and control modules.
4) Trunk Usage—The investment with usage sensitive trunk-side switching. It is composed primarily of digital trunk controllers, DS1 links, and the network module.
5) Umbilical Usage—The usage sensitive investment in host-remote links.
6) SS7—Investment associated with the Signaling Point/Service Switching Point (SP/SSP) located in the central office.


Data Collection
Regression Process
FCC Investment Data
User Defined Factors
Ia. Switch Functional Investment Development Process
Vendor Discounts
BCPM Data Flow
Data Collection (Switch Op. Environment)
Functional Investment Development
Switch Investment Refinement Process
Installed Investment Process
Unitizing Process
Ib. Company Specific Inv. Data
II. Service Specific Investment Process
1. Define and Analyze Cost Objects
2. Define Switch Resource Use
3. Collect Demand and Customer Characteristic Data
4. Develop Investments
Service Specific Investment Process
BCPM Data Flow
Data Collection

Functional investments can be developed via two distinct methods. The first is direct input is from an Audited LEC Switching Model (ALSM) and the second is the Functional Investment Development Process. The first can be implemented when detailed switching information is available for each specific switch. This is typically the case with larger LECs and is generally the output provided by their respective ALSMs. This method may typically be used in state specific hearings dealing with UNEs. If this approach is used, the ALSM output is input directly into the Service Specific Investment Process. The second approach is more appropriate in a USF setting or when detailed specific switch by switch data is unavailable. This second approach will be referred to as the Functional Investment Process. The steps in the Functional Investment Process are:

- Data Collection and Regression
- Functional Investment Development
- Switch Investment Validation Process
- Installed Investment Process
- Unitizing Process

Data Collection and Regression Process

Initially, BCPM2 Sponsor Companies will provide non-discounted total Functional investments[3] for statistically valid samples of 5ESS®, DMS-100®, and DMS-10® switches, and their associated remotes, covering a reasonable range of switch sizes and remote sizes. This same data may be derived from alternative data provided by the FCC. Data for additional switch types and vendors could be added in later versions. In addition, we shall welcome the inclusion of sample switch investments provided by LECs other than the Sponsor Companies or switch vendors themselves. The Sponsor Companies will develop these investments by running ALSMs using detailed engineering data for the switches studied. This data will include the total switch investments for each of the Functional Investment categories outlined above.

Each Functional Investment sample will be used as a dependent variable in a regression function. Regression analysis entails regressing total switch investment utilizing a set of multiple independent variables., e.g. number of lines, number of trunks, that explain changes in total switch investment. The regression coefficients indicate the dollar change in total switch investment for a one unit increase in the independent variable. For example, if the coefficient on number of lines is 175 this indicates that increasing the number of lines by one causes a $175 increase in total switch investment. Once these coefficients have been estimated, detailed data on these independent variables for specific serving wire centers enable the analyst to estimate the total switch cost associated with that serving wire center.

[3] The data will include vendor provided Engineering, Furnishing and Installation (E,F&I).

The dependent variables may be regressed against (but not limited to) the following independent variables, which will be drawn from publicly available data bases that will be incorporated into the BCPM2 input data flow:

- Host / Remote Indicator,
- Host Business Lines,
- Remote Business Lines,
- Host Residential Lines,
- Remote Residential Lines,
- Total Lines,
- Number of Remotes,
- Density Indicator,
- Switch / Remote Vendor / Type, and
- Busy Hour Holding Time[4].

The ALSM runs will also collect appropriate information on the switch (data that will be available in the BCPM public data sources) to allow further analysis of additional factors related to the cost of switching. These analyses are discussed in the Switch Cost Refinement section below.

This regression process will result in a coefficient matrix of Switch Functional Investments by BCPM2 Input Data combinations[5]. At this point, the user could substitute other known relationships for the values in the coefficient matrix.

Functional Investment Development

This module creates the default investment values for the functional investment categories.

- Once the regression coefficient table has been developed from the step above, preliminary switch functional investments can be developed by multiplying the BCPM Input Data values (either user input or flows from other BCPM system modules) for each switch and remote CLLI for the study area by their corresponding regression coefficients. These BCPM input data values will be the same as those used to develop the regression coefficients from the sample switches.

[4] Busy Hour Holding Time will be calculated based on Dial Equipment Minutes which will be converted into Busy Hour CCS and the number of lines for each switch.

[5] Alternative approaches will be investigated based on forthcoming FCC data.

During this process, two additional sub-routines will perform the following functions. These functions will be user controlled via table inputs.

- **Maximum Switch Size**
  The user will be able to define the maximum switch size by setting limits upon three switch parameters: Number of Lines, Total Busy Hour CCS, and Total Busy Hour Call Attempts. The algorithm will determine values for each parameter using the public Input Data accessed by the model. If a wire center exceeds any one of the parameters then the sub-routine may insert an additional switch or switches and then evenly spread out the total line demand at the location among the additionally assigned switches or remotes. Later those wire centers with multiple switches or remotes will have their calculated Functional Investments recombined.

- **Surrogate Switch / Remote Matching**

  If Switch Vendor / Type is included as part of the BCPM2 Data Input stream, then switches and remotes that do not match the three available options for switches (i.e., 5ESS®, DMS-100®, and DMS-10®) and remotes will have a Switch or Remote Vendor / Type logically assigned.

Switch Investment Refinement Process

This process will match and then true up the calculated investment for each CLLI from the above step to its respective vendor invoice investment as reported to the FCC. This process begins by multiplying the Switch Functionals Investments by a user-definable Vendor Discount, then summing the discount adjusted Switch Functional Investments for each CLLI. The summed Functional Investments are then matched to the reported investments. Differences will be eliminated by applying a ratio factor developed by dividing the calculated investments into the reported investments. The model will apply this ratio factor to each of the Functional Investments for each CLLIs. The result will be a matrix of validated Total Switch Functional Investments by CLLI code and functional category. If FCC data is not available for any particular switch, the output from the Functional Development Process will be passed though.

Installed Investment Process

The Switch Investment Refinement process results in a number that represents the material cost from the vendor for the switching equipment. To develop the total Installed (working) investment, investment loading factors must be applied to account for the additional activities and equipment necessary to install and support the switch. The factors applied are as follows:

- LEC In-Plant Factor - Telephone company labor and material needed to install the switch.
- Land and Building Factors - Central office floor space required by the switch.
- Power and Common Equipment Factors - Central office powerplant equipment and miscellaneous equipment such as racks and bays needed to support the switch.
- Sales Tax - In many states, sales tax is applicable to the material portion of the switch investment.

The output of this process is a matrix of Installed Total Switch Functional Investments by CLLI code and functional category.

Unitizing Process

This process will break the Installed Total Switch Functional Investments down into Unit Switch Functional Investments for each CLLI code. The unitizing will be accomplished by dividing the total line investments by the number of lines in each CLLI and the CCS related investments by the calculated Busy Hour CCS for each CLLI. The result will be a matrix of Unit Functional Switch Investments by CLLI code and functional category.

Ib. Company Specific Data

There may be cases where the investments estimated in this process may not be appropriate for specific State or Federal proceedings. In these cases, actual data from a company's ALSM may be substituted directly into the process.

II. Service Specific Investment Development Process

The purpose of the Service Specific Investment Process is to calculate the per unit switching investments for universal service or for UNEs. The switching investments are later combined with other investments, for example transport and signaling investments, to produce a complete cost study for the service or rate element.

The BCPM-SM Service Specific Investment process has four major steps:

- Define and Analyze Cost Objects
- Define Switch Resource Use
- Collect Demand and Customer Characteristic Data
- Develop Investments

In each of theses steps, there will be user inputs in the BCPM-SM that allow the user to control the process.

Define Cost Objects

This step is perhaps the most critical because it drives the application of the remaining steps. The user thoroughly defines, from both operational and engineering points of view, the scope and application of the service or rate element (cost objects) being studied. For example, for universal service, the model must distinguish between usage that is attributable to local/EAS calling and that attributable to toll calling. The study must further define the fact that local calling is separated into interswitch calling and intraswitch calling. A key data input into this process is the proposed service tariff which defines contractually the service functionality being provided to the end user.

The preceding distinctions are critical because if they are conducted incorrectly, the remaining steps yield inaccurate results. For example, if the distinction between toll and local calling is not explicit, then the study may not separate the total line usage into the two categories, thus, overstating the cost of universal service (or misstating the cost of the UNEs). Likewise, if the distinction between interswitch calling and intraswitch calling is not understood and incorporated into the modeling and data collection processes, then the study will be incorrect because the two types of calling use resources from different switch functional cost categories. The rate structure of the cost object is critical. For example, a service that is priced per minute is a significantly different cost object from one that is flat-rated. While both begin with the same functional switch resource investments, there are critical differences in the data inputs and final cost calculations.

The BCPM-SM will come pre-loaded with what the Sponsors believe to be a complete list of services and/or rate elements. However, these values will not be hard-coded in the Model. Rather, the user will have the choice to retain the current items, modify existing items, or add new ones.

Define Switch Resource Use

Once the cost object is defined, the functional investment categories to be used are identified. For example, the local usage element invokes a Getting Started investment because it uses the processor for call setup. In addition, there are Line Usage and Trunk Usage investments because the cost object involves intraswitch calling and interswitch calling. Finally, SS7 investments are needed for signaling to set up interoffice calls.

The Model must not only define what functional switch resources are used, but how much of each resource is used for each use of the cost objects. For example, the analysis may determine that each call attempt uses 10 processor milliseconds and generates 125 SS7 octets.

The BCPM-SM will come pre-loaded with what the Sponsors believe to be the correct relationship between the functional elements of the switch and the service or rate element being analyzed. In addition, support for these default inputs will be provided. However, the Model will not be hard-coded with these values. Rather, the user will have the choice to retain or modify the relationships.

Collect Demand and Customer Characteristic Data

Demand data defines how many times in a typical busy hour a customer uses the cost object. For example, a customer may make on average, 2 local calls in the office busy hour. Characteristic data defines how the customer uses the service. A customer may have a holding time of 180 CCS, or three minutes per call. Again, proper definition of the cost object is critical. If the distinction between local calling and toll calling is not made, then the study may be seriously in error.

The BCPM-SM will also come pre-loaded with what the Sponsors believe to be the correct usage of the functional components of the switch by the service or rate element being investigated. In addition, support for these default inputs will be provided. However, the Model will not be hard coded with these values. Rather, the user will have the choice to retain or modify the usage relationships.

Develop Investments

The final step is to apply the service-specific algorithms and data to the Unit Functional Switch Investments to produce service or rate element costs. Here is a simplified example of the calculation of a flat-rated local usage investment of the type needed for universal service:

Unit Functional Switch Investments

A. Getting Started Investment per Millisecond: $0.30
B. Line Usage Investment per Busy Hour Minute: $5
C. Trunk Usage Investment per Busy Hour Minute: $4
D. SS7 Investment per Octet $0.00004

Input Data

E. Processor Milliseconds per Call Setup: 20
F. Average Minutes per Call: 3
G. Average Local Calls per Busy Hour: 2
H. Percent of Local Calls that are Interoffice: 30%
I. Number of SS7 Octets per Call Setup: 125

J. Investment per Busy Hour Call Setup

J = (A*E) + (D*I)
= (.30*20) + (.00004*125)
= $6.005

K. Investment per Busy Hour MOU

K = (B*2)+(C*2*H)
= ($5*2) + ($4*2*30%)
= $12.40

Total Busy Hour Local Usage Investment per Line

Total Investment = (J*G) + (K*F*G)
= ($6.005*2) + ($12.40*3*2)
= $86.41

In this example, the Local Usage investment for Transport, Signaling, and Tandem Switching would also be included to develop the total Local Usage Investment. Finally, the Line Port Investment would be calculated to produce the total investment for universal service, per line.

CONCLUDING REMARKS

The BCPM-SM provides the user with tremendous flexibility. This flexibility extends well beyond user prescribed inputs, to methodological approaches that can be utilized to generate the per line switch investment associated with basic service and the appropriate per unit switch investment associated with various UNEs.